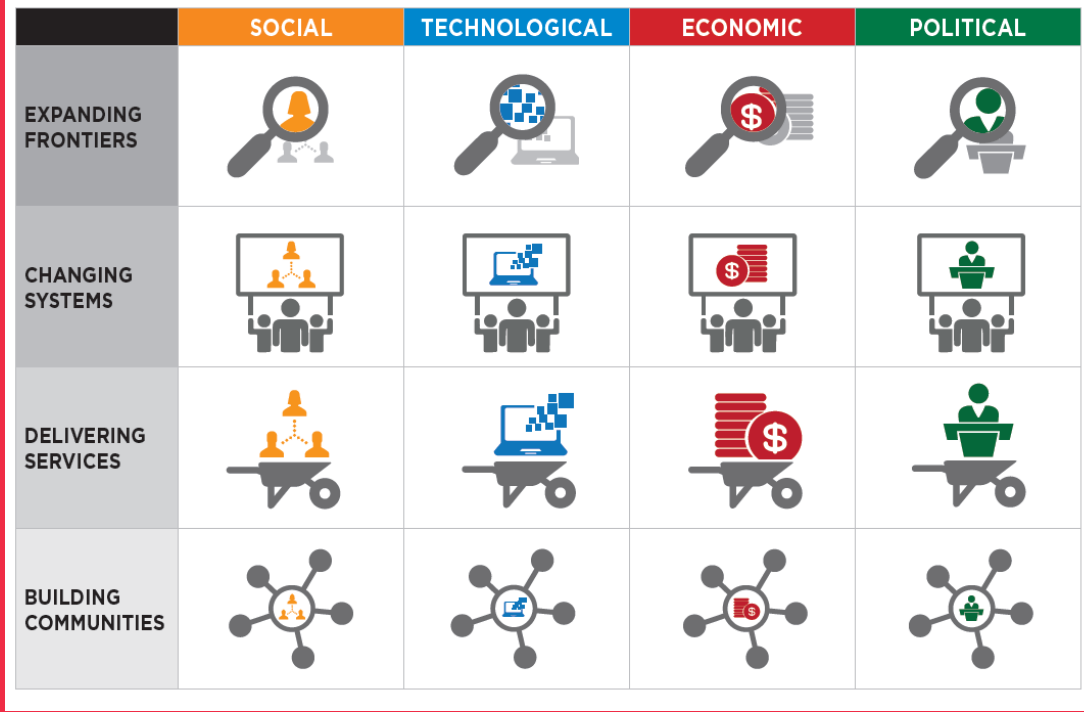
DISTRIBUTED**FUTURES**

An open source research programme for
Smart Ledgers and new technologies

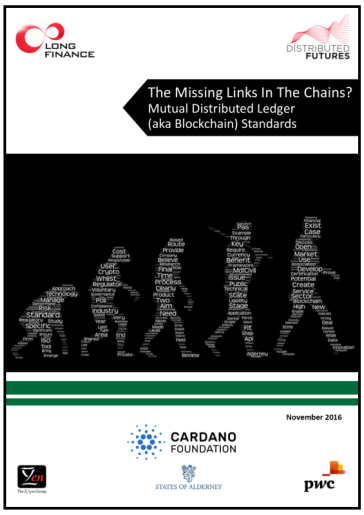
OUR RESEARCH STRUCTURE



The Missing Links In The Chains?

Mutual distributed ledger (MDL, aka blockchain) technology has captured a great deal of attention. As with any new technology, MDLs expose organisations to new risks. Where do existing standards cover the risks and where might new standards be necessary?

Overview



Regulators have responsibility for protecting consumers and overseeing the integrity of markets and typically respond to risks through the establishment of specific regulations, or by encouraging the establishment of voluntary standards markets.

This study looks at the risks of MDLs, examines how MDLs could fit within a regulatory framework, identifies aspects of MDLs that would benefit from the development of standards, and assesses the development paths that could be used to create standards.

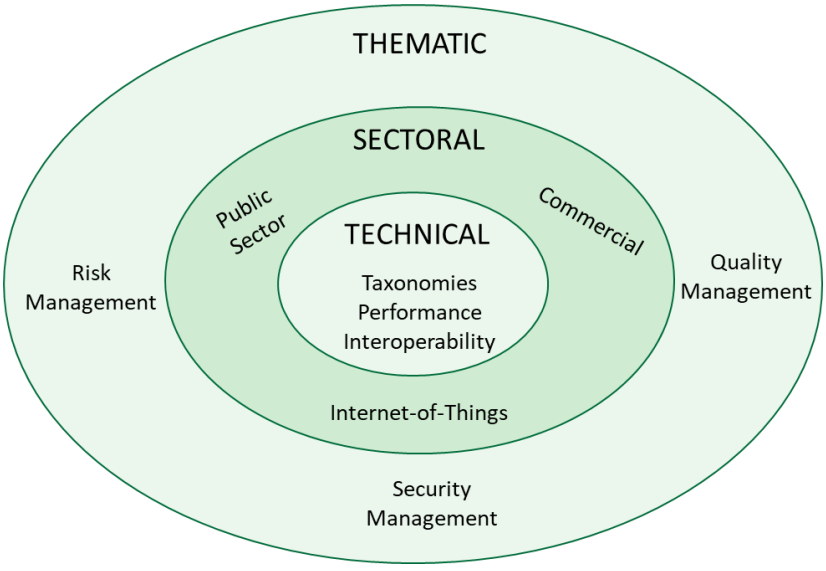
Supported by a series of expert interviews, a workshop and webinar, the study identifies three levels at which regulatory standards can be applied to MDLs: Thematic, Sectoral, and Technical.

For sector-specific MDLs, for example, three issues were identified as areas that would benefit from the development of significant voluntary standards: Taxonomies & Performance, Data Governance & Liability, and Commercial Governance & Liability.

Report Extracts

A **voluntary standards market** is "a commercial system in which actual and potential buyers and suppliers of products and services rely on conformity assessments". Conformity assessments are carried out against standards and can consist of self-certification, second party and third party independent verification, and certification. Voluntary standards are typically developed on the basis of consensus of all interested parties, are subject to unrestricted open consultation, and undergo systematic review to ensure their continued validity.

The Standards Environment For MDLs

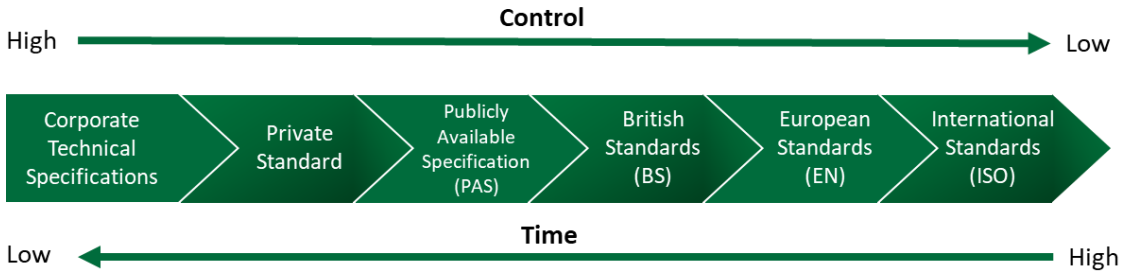


Report Extracts

Comparative Advantages & Disadvantages Of Regulation & Standards

	Advantages	Disadvantages
Regulation	• Necessitates corporate buy-in • Standardisation • Certainty • Level playing field—no free riders • Comparability • Legal certainty	• Knowledge gaps between regulators and industry can result in poorly constructed regulation • One size rarely fits all • Places constraints on innovation • Constrains efficiency and competitiveness • Lack of flexibility in the face of change and complexity
Voluntary Standards	• Flexibility—appropriate for a range of sectors and sizes • Proximity—industry derived standards are efficient and effective • Transparency—standard and compliance in public • Efficient—costs of auditing, verification, and accreditation borne by industry • Comparability/competitive advantage	• Credibility of standard • Management buy-in required • Competition between standards—race to the bottom? • Resource intensive • Sanction free

Types & Evolution Of Standards



Conclusions

Given that MDLs are databases, a specialised MDL professional qualification is not necessary at this time. The consensus from interviewees was that MDLs would benefit from the development of a voluntary standards market and that technical standards dealing with performance and interoperability will emerge naturally. In regards to thematic standards, existing frameworks such as ISO 9000 or ISO 31000 are flexible enough to be adapted for use with MDLs. However, for sector-specific standards, significant voluntary standards market development could be supported in three areas: taxonomies and performance standards, data governance and liability standards, and commercial governance and liability standards.

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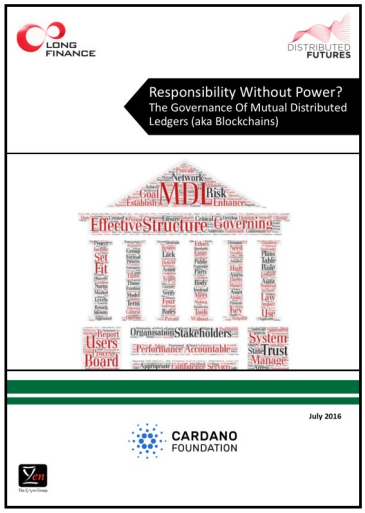
Responsibility Without Power?

The Governance Of Mutual Distributed Ledgers (aka Blockchains)

Although Mutual Distributed Ledgers (MDLs) are often referred to as 'trustless networks' due to the way that transactions are managed, in reality, trust and effective governance are critical factors in the success of an MDL.

Overview



Mutual Distributed Ledger (MDL, aka blockchain) technology is, still, in an emergent phase. New applications are under development; new uses are being researched; new consortia are being formed to explore MDL applications. Considering appropriate governance structures has had a lower priority so far, but trust in the increasingly popular systems will depend on their incorporating good governance principles. It was the aim of this study to identify those principles, in order to provide a roadmap for developers and users alike.

An analysis of the material collected through desktop research, as well as several discussions with practitioners and stakeholders including a conference and webinar on the subject, has revealed that effective governance in Mutual Distributed Ledgers (MDL) systems relies on people rather than software and should seek to answer four critical questions:

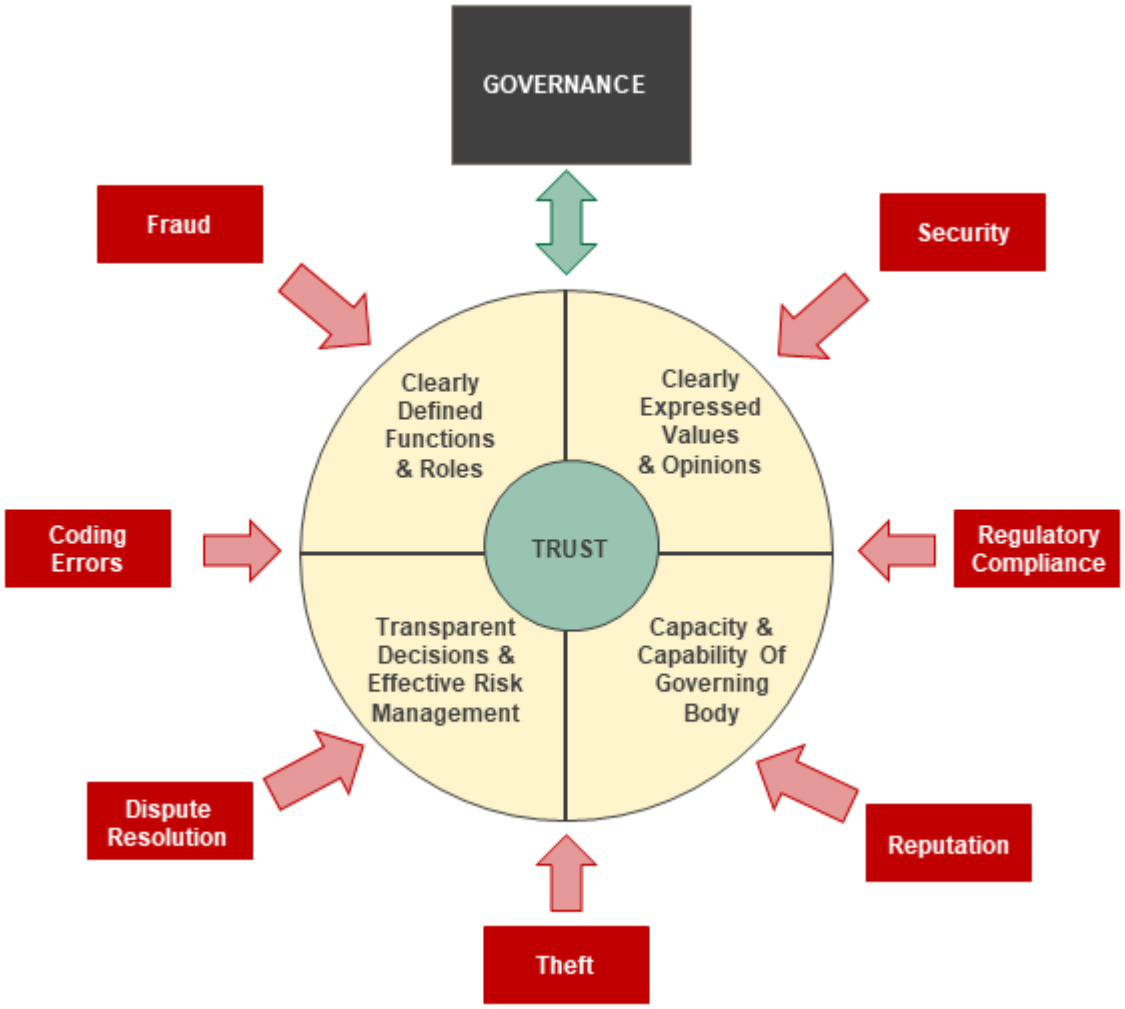
- How are rules created for the ledger and who oversees their application?
- What happens in the case of dispute?
- Who is allowed to change the software application and the data?
- How are security, risk, and performance managed and reported?

Report Extracts

Governance Structure	Use Class
Co-operative: An autonomous association, jointly owned and democratically controlled.	**Public MDLs (Un-permissioned)**: Little formal governance structure, *e.g. Crypto-currencies.*
Appointed Board: Board members are appointed by stakeholders, or the board itself, to bring particular knowledge and skills to the table.	**State sponsored MDLs (Permissioned)**: Governance structures of sponsoring agencies grafted on, *e.g. land registries or identity.*
Oligarchy: The individuals that comprise the board are the owners or stakeholders.	**Private MDLs (Permissioned)**: Highly defined governance structure, *e.g. platforms for blockchain -based applications for business ecosystems.*
Membership: Board members are elected to their positions and tenure is for a fixed period.	**Consortium MDLs (Permissioned)**: Established and managed by a group of organisations rather than a single entity, likely to have a complex governance structure, *e.g. Financial Services or Internet of Things (IoT) platforms.*
Representative: For organisations that wish to have members who are enterprises instead of individuals. This structure may be appropriate for both consortium and state-sponsored MDLs.	**State-Sponsored and Consortium MDLs (Permissioned, see above)**

Report Extracts

Factors Affecting Trust In MDL Networks



Conclusions

Governance, which enhances trust in MDL systems, rests on three pillars:

Architecture: The role of the governance structure, its composition, remit, powers, responsibilities, and relationship with users is a critical component.

Accountability: Effective governance of MDLs creates confidence for stakeholders. Appropriate confidence is enhanced when a governance structure is accountable to its stakeholders, transparent and predictable in its decision-making, and has strong ethical foundations, particularly with respect to access to justice.

Action: The governance structure must develop strategic and risk management plans, which are delivered through effective performance management frameworks. Confidence can be enhanced through the use of voluntary standards to verify independently performance metrics and systems created to compile them.

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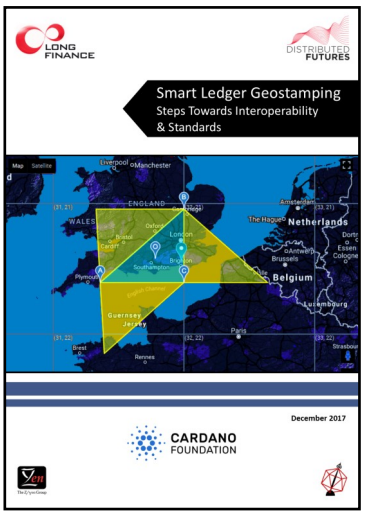
Smart Ledger Geostamping

Steps Towards Interoperability & Standards

The adoption of a limited number of georeferencing structures that have global applicability should ease one area of inter-operability for Smart Ledgers, namely sharing geospatial information.

Overview



Smart Ledgers (aka blockchains) provide a facility for recording immutable transactions. This takes the form of a 'timestamp', a permanent record of computer-based transactions. A natural extension is to add other information, like, for example, a 'geostamp'.

A geostamp is a digital record of the geographic location of a transaction or, in other words, a timestamp with a geographic location attached. A geostamp uses geocoding or georeferencing, the assignment of a unique identification to a place on the earth represented by a point, line, or area.

We are all familiar with certain forms of geocoding, like longitude and latitude, post codes, and zip-codes. However, the adoption of a limited number of consistent geocoding structures that have global applicability could increase interoperability of Smart Ledgers.

Distributed Futures has an open source resource project, GeoGnomo (geognomo.com), to research and share methods for geostamping. Based on the four principal qualities encapsulated in the 'MAPS' acronym, namely, Memorability, Aggregation, Proximity, and Scale, it has developed three methods for geocoding, two of which use rectangular areas, and the other, triangular ones.

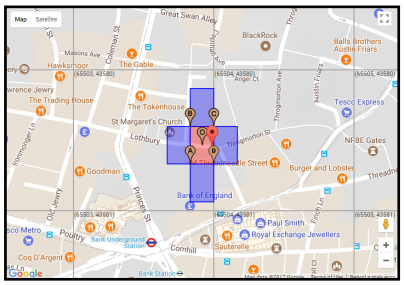
Report Extracts

The principal qualities of a good geocode can be encapsulated in the 'MAPS' Acronym.

M	Memorability	A geocode should be compact and memorable
A	Aggregation	A coding system should be able to describe comparably a variety of area sizes and structures, both natural and human, such as forests, beaches, buildings, sports grounds, country borders, etc.
P	Proximity	Similar codes should represent similar locations, so that people exchanging codes can roughly understand the distance and relationship between them
S	Scale	Users should have control over the precision

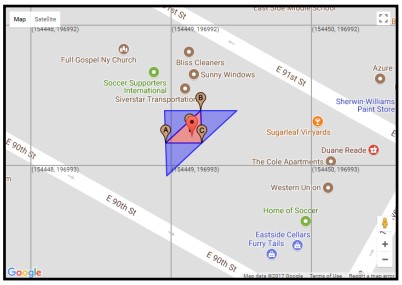
Report Extracts

The **Quaternary Rectangular System (QRS)** divides the globe in eighteen 60 by 60 degree squares, by dividing latitude into 3 bands and longitude into 6 bands, and assigns a geocode to each one. These 18 squares form the grid at level 0 and each can be subdivided with no exceptions. The higher the level, the smaller the area covered by each square.



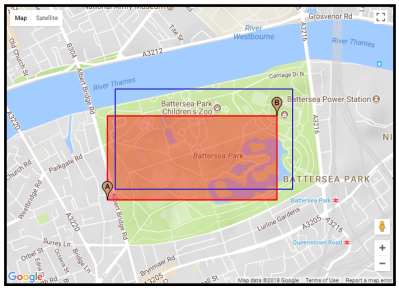
City of London at level 17
QRS:G5V4UW7F-17

The **Quaternary Triangle System (QTS)** divides the globe into a fixed grid of triangles and assigns a unique geocode to each. Starting with an icosahedron that forms the grid at level 0, each of the 20 equal triangles is divided to 4 equal triangles, forming the grid at level 1, and so on and so forth. QTS is very similar to QRS, with the major difference being that one uses a grid of squares and the other a grid of triangles.



Computer Location in New York City at level 19 QTS:E8VQAFJVA-19

The **Variable Rectangular System (VRS)** generates codes from a rectangular area, specified through a 'click and drag' selection to represent the selected area. Once the area has been selected, the approach is to round the coordinate values so that the information can be stored in a code of memorable length, but the 'rounding' is chosen so that the area retains a relatively close approximation to the original. Different levels cannot be specified in VRS been chosen, they are organised in a predetermined way into a numerical code that reproduces the rectangle.



Battersea Park VRS:RUYQ785HM8

Conclusions

Developers and users of Smart Ledgers, and other recording systems, may find that the addition of geocodes from the GeoGnomo project help to simplify human-system interaction. The use of geocodes reduces human error and eases human data retrieval. GeoGnomo is an ongoing research project and there may well be further geocoding approaches.

Try finding your home's geostamp at www.geognomo.com
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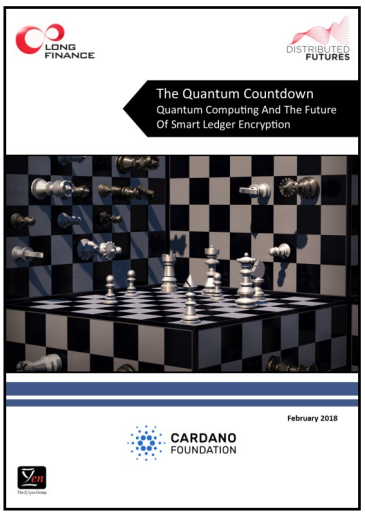
The Quantum Countdown: Quantum Computing And The Future Of Smart Ledger Encryption

The development of large-scale quantum computers will threaten the security of computer networks and services that depend on public key encryption, including Smart Ledgers. How real is the threat and how and when should we start preparing for it?

Overview

The post-quantum cryptography ("PQC") problem will threaten the security of the world's computer networks when large-scale quantum computers become available. The problem exists because such quantum computers would be able to break the security of widely-used public key cryptography, which allows remote parties to communicate securely and authenticate transactions and data without sharing a secret key in advance. It is uncertain when (and if) such quantum computers will become available - the nearest estimates are 10 to 15 years.



Fortunately, there are good solutions to the PQC problem, and better ones are emerging. The hard questions for individual computer system operators involve when and how to address the PQC problem, given its uncertain timing and the evolving solutions.

The report explains the PQC problem in detail for both non-technical and technical readers, starting with the essentials of cryptography, quantum computing, and how quantum computing threatens public key cryptography. We then consider the available solutions to the PQC problem, and provide frameworks for deciding when and how to respond to it.

Report Extracts

Classical versus Quantum Computers

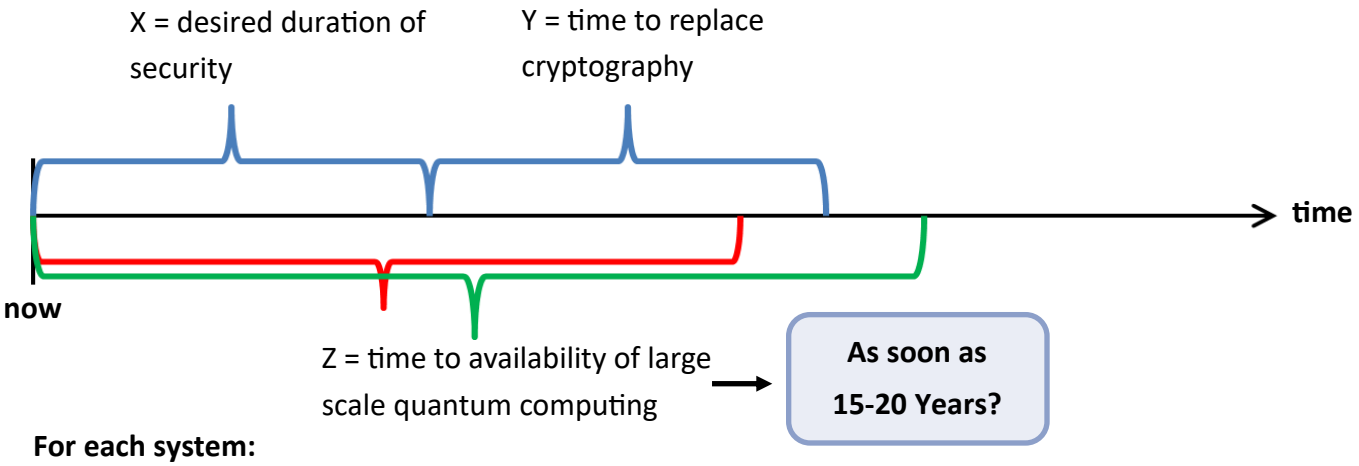
In a classical computer, eight bits of memory (or one 'byte', often corresponding to one character) can hold any of 28 = 256 different values. In a quantum computer, eight entangled qubits (quantum bits) hold all 256 values at the same time, and a program running on the computer could theoretically determine in a single step which of the 256 states is most likely.

Risks to Blockchain Architectures from Quantum Computing

	Transactions	Data on Blockchain	Software on Blockchain
Read historical records without authorization	No (blockchains are intended to allow access to transaction information)	No, unless confidential and secured with vulnerable cryptography	No, unless confidential and secured with vulnerable cryptography
Alter historical records	No	No	May be able to run software without authorisation if signature used
Spoof ongoing records	Yes, possibly	Yes, possibly	Yes, possibly

Report Extracts

The Mosca Inequality



For each system:

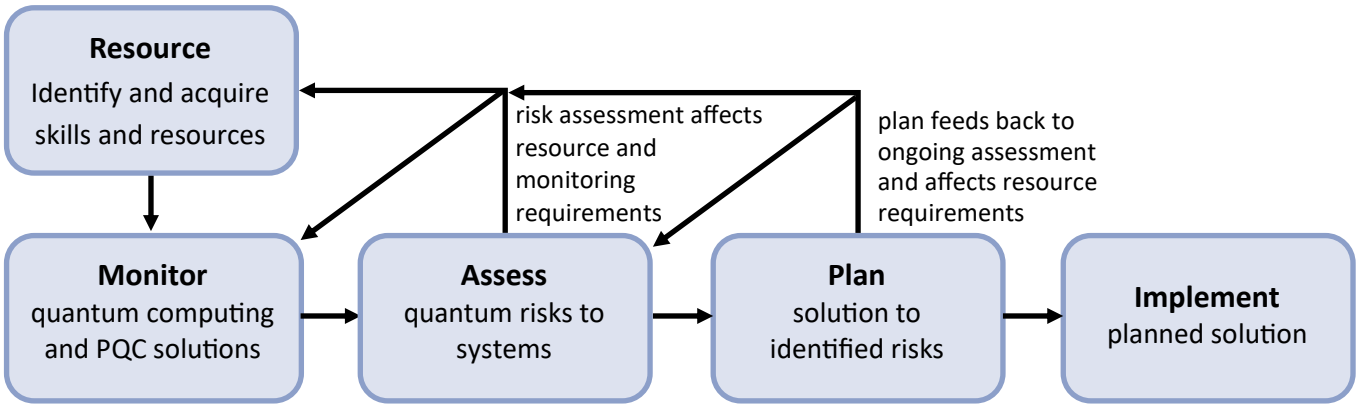
If X + Y < Z, there is time to act
If X + Y > Z, it may already be too late to entirely avoid the post-quantum cryptography problem

Some systems may fall into the second category – a particular issue for Blockchain/Smart Ledgers, where X is very large

Conclusions

The sky is not falling. However, action may be appropriate now for Smart Ledgers and other computer systems that (i) are new (to avoid later redesign), (ii) have large consequences associated with insecurity and/or (iii) require security of long duration.

Framework for Addressing the PQC Problem



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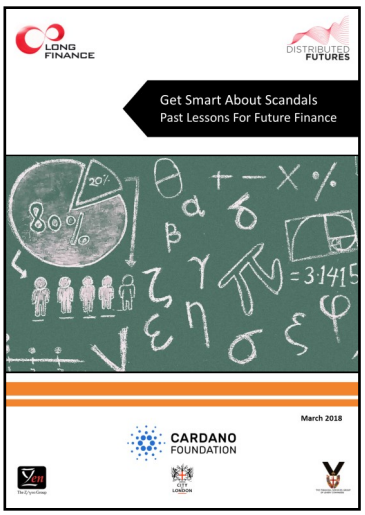
Get Smart About Scandals

Past Lessons For Future Finance

At a time when the velocity of change in technology and systems is challenging the business and economic models for conducting financial services, it is prescient to analyse the cause and effect of financial scandals past and present.

Overview



The financial world is shaken at intervals by scandals or revelations involving activities which, although not strictly speaking legal, provoke a level of moral indignation.

So what defences can be set up to ensure that corruption and scandal are to be prevented or at least avoided? Since the banking crash of 2008 in particular, compliance has become a major issue. Transparency, in turn, has become a rather over-used word, but is still a valuable concept. Smart Ledgers should prove to be a workable system that will cast light into dark corners and will prevent the continuing existence of what are sometimes referred to as Old Spanish Practices. It will hopefully reinforce confidence in companies, the system and financial centres, which is all to the public good.

Measures need to be considered in ensuring that different working practices will become the industrial standard. There needs to be a clear policy on ethical issues at individual and company level, backed up by a system of oversight and compliance that can function without being obtrusive. So it is worth looking at such financial scandals, the circumstances which engendered them, and the measures taken both before and after which were designed to prevent them, in order to see whether there is a discernible pattern which can be traced and therefore classified and used in the hope that such things can be headed off or even avoided in future.

Report Extracts

The Mississippi Bubble 1718

When King Louis XIV of France died, his opulent lifestyle left the country in dire financial straits. John Law, an itinerant Scotsman, persuaded the Duke of Orleans that he had a cunning plan to resolve the problem: a state-owned bank would issue a fiat currency by taking in gold and issuing paper money – which could be redeemed in due course at face value. The state would therefore be able to lend money to entrepreneurs, and thereby invigorate the economy and recoup the benefits via taxation. Phase 2 was to launch the Mississippi Company, along the lines of the East India Company which had created so much wealth for Holland. However, Louisiana was little more than a swamp at the time and did not yield the returns anticipated. John Law increased the nominal value of the Company by issuing further stock. At this point some investors became justifiably anxious and tried to withdraw their funds. The reserves were not there and the crash was spectacular.

Report Extracts

Vehicles for Fraudulent Behaviour	Corrupt Practices And Procedures	Bubbles, Booms And Busts
Technology Opens New Horizons for Fraudulent Behaviour	Taxation: Its Role In Corrupt Practices	Bubbles, Booms And Busts Are Unexpected Periodic Events
The Madoff Scandal	Tax Heavens or Havens?	Bubbles Or Waves?
The Enron Scandal	The Legal & Moral Dilemmas of Globalisation?	The Poseidon Bubble
Pyramid Selling	No Room For Complacency In Combating Intrusive, Questionable And Illegal Activities	The Dot.Com Boom And Bust
Cyber Crime - An Emerging Developing Form of Financial Crime	Enterprises Disguise Illegal Activities Internally	Cryptocurrencies – A Suitable Case For Treatment Under Boom And Bust?
Criminal Authorities: Behaviour & Reaction	Rules & Regulations – A Response To The Global Financial Crises Since 2007	"Cash Is King" In A Financial Crisis
Globalisation, Digitisation And Growth Of Financial Crime	The Moral Hazard of Lehman Brothers, Northern Rock & Others	The Financial Risks Of Cash Markets
Cryptocurrencies: Don't Confuse The Technology With The Product And Service	Moral Hazard And Government Intervention	Controlling Economic Development During Market Booms
Growth Of Products And Services Derived From Cryptocurrencies	A Post-Mortem On The Global Financial Crisis	Factors Contributing To A Boom

Conclusions

- There is too much detailed regulation.
- Regulations are too complex to detect or prevent financial scandals.
- One size of regulation does not fit all.
- Although current forms of sanction for violation of financial regulation are severe, they don't seem to deter scandals.
- Adherence is paid to the forms and processes of regulation as much as the substance.
- Advances in globalisation present complexity and conflicts across jurisdictions arising from differences of business culture and ethics.
- Major financial centres have to develop their own specific agents of change to address financial scandals.

Measures need to be introduced in the four key areas of: **Policy, Procedures, Structures, and Training**. Recommendations include:

- Reviewing the financial regulatory and compliance procedures
- Strengthening identity and verification checks on new enterprises
- Drawing on a wider range of skills and resources to pursue e-criminals, with support from commercial and law enforcement agencies.
- Review and develop programmes for teaching ethics.

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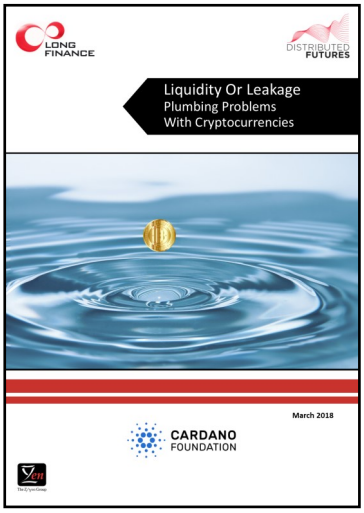
Liquidity Or Leakage

The governance of cryptocurrencies requires a more clearly defined link between their novel money supply algorithms and traditional economic and financial analysis.

Overview



Liquidity is the probability that an asset can be converted into an expected amount of value within an expected amount of time. Any token claiming to be 'money' should be very liquid.

Cryptocurrencies often exhibit high price volatility and wide spreads between their buy and sell prices into fiat currencies. In other markets, such high volatility and wide spreads might indicate low liquidity, i.e. it is difficult to turn an asset into cash. Normal price falls do not increase the number of sellers but should increase the number of buyers. A liquidity hole is where price falls do not bring out buyers, but rather generate even more sellers.

If cryptocurrencies fail to provide easy liquidity, then they fail as mediums of exchange, one of the principal roles of money. However, there are a number of ways of assembling a cryptocurrency and a number of parameters, such as the timing of trades, the money supply algorithm, and the assembling of blocks, that might be done in better ways to improve liquidity.

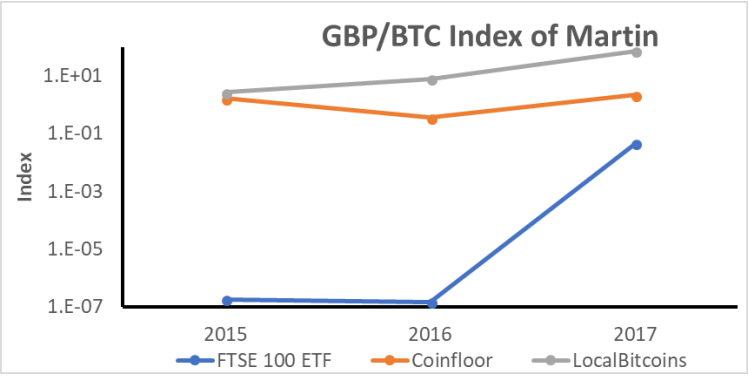
The report aims to help policy makers look critically at what's needed to provide good liquidity with these exciting systems.

Report Extracts

The Index of Martin

The Index of Martin is a convenient metric that allows for the comparison of the liquidity levels of different classes of assets.

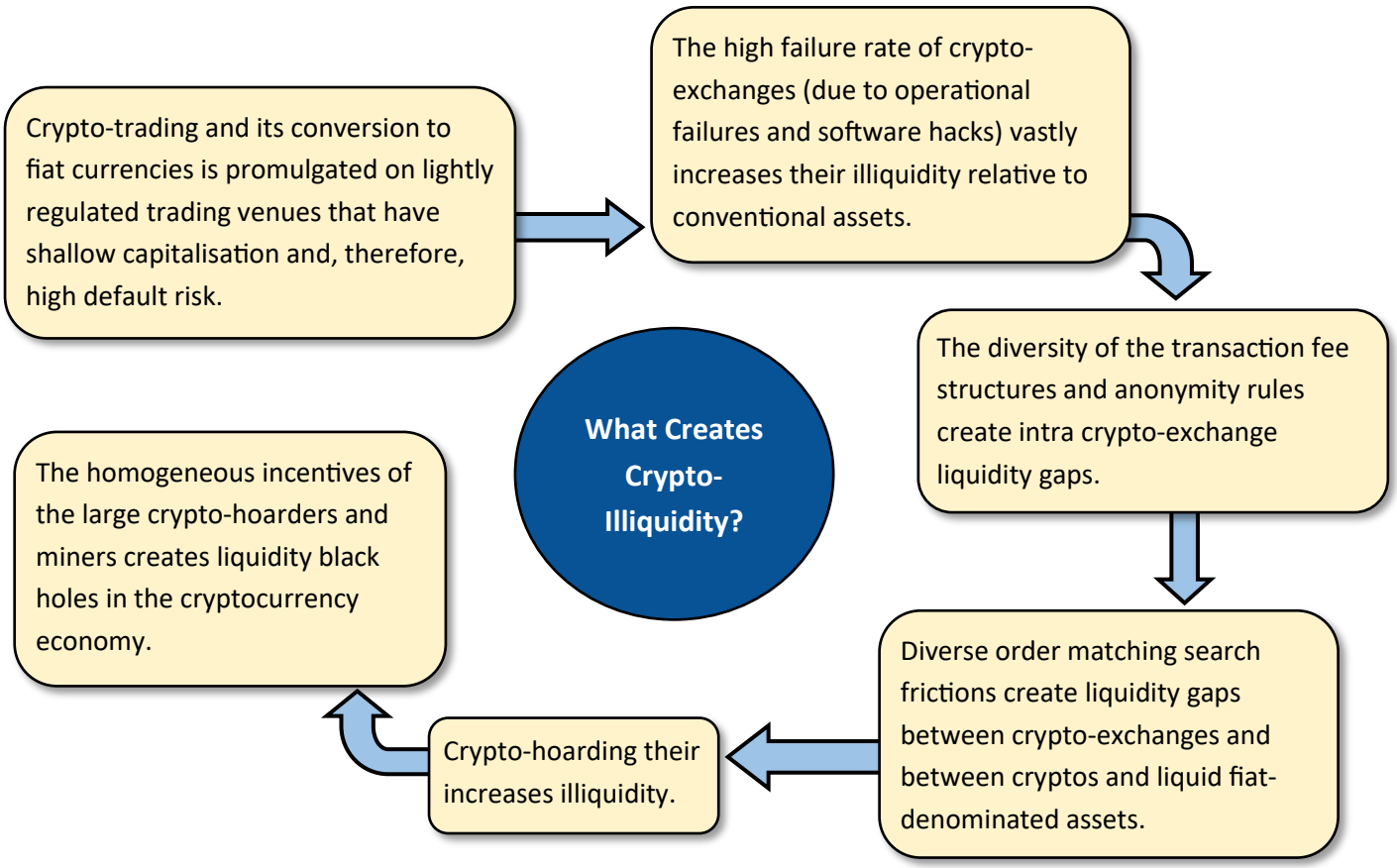
Martin (1975) proposes a liquidity index (MLI) given an assumption that a stationary distribution of price changes hold through the entire transaction time. A high value of MLI indicates less liquidity of a stock. The higher value of the ratio means the larger price dispersion corresponding to the traded volume.



The Index of Martin shows us that:

- The Bitcoin markets are at least two orders of magnitude more illiquid than the large-cap equity market ETFs. This would help explain the outsized returns (due to the illiquidity premium) observed in the Bitcoin markets.
- Bitcoin illiquidity increased at least an order or magnitude from 2016 to 2017. Again, this illiquidity uptick contributed to the enormous 2017 Q4 returns observed in the Bitcoin markets.
- There are material liquidity gaps between the different crypto-trading venues.

Report Extracts



Conclusions

- Mutual Distributed Ledgers should employ best practice software development processes and information security protocols
- The impact of Meltdown and Spectre on MDLs and crypto-wallets has yet to be quantified but may be quite severe
- The extreme illiquidity and hyper-volatility make cryptocurrencies compelling assets for speculators, but diminish their value proposition for vendors and regulated financial service firms
- The Index of Martin is a simple liquidity monitoring metric that can indicate the occurrence of 'illiquidity pops' in the cryptocurrency markets
- ISDA standardisation of smart legal contracts will support scalability of these digital contracts, helping to cement their adoption by global investment banks
- The United Kingdom's common law system is inherently flexible enough to facilitate smart legal contracts and to quickly respond to the opportunities and challenges that they may present (including the question of enforceability)
- The OTC derivatives market must embrace transformational change to realise the cost-saving benefits of smart derivative contracts

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The Economic Impact Of Smart Ledgers On World Trade

Can Smart Ledgers be potential facilitators of global trade flows? Conceptually, the impact of Smart Ledgers will be realised by reduced cost frictions associated with processes such as paperwork and identity checking, facilitating the creation of new business opportunities, and reducing the volatility associated with international trade.

Overview

The report measures the impact of Smart Ledger through a number of different channels, ranging from the direct barrier reductions on trade to volatility reductions. The report also assesses the potential global economic impact of related technologies.

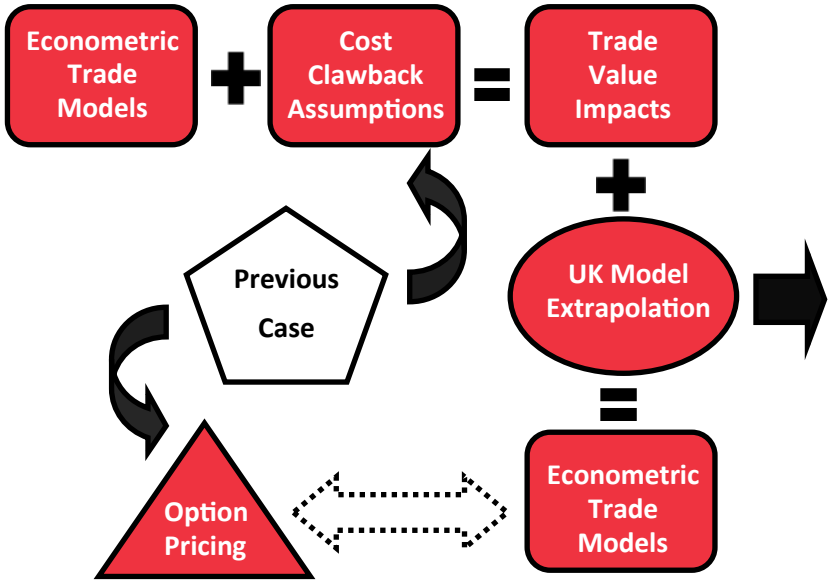
Smart Ledgers could conservatively result in approximately $35 billion in extra global trade on an annual basis, based on a range of assumptions regarding the potential cost savings and the respective trade transmissions. Assuming that the import savings costs are symmetrically replicated in terms of export savings, the global trade boost could rise towards $70 billion per annum.

With a bolder assumption that there was a symmetrical cost clawback on both imports and exports of 5%, as opposed to the 2.5% baseline assumption, then the value impacts could rise significantly.

We adapted an option pricing model to show the potential gains associated with the volatility reduction properties of Smart Ledgers. We estimate that these savings could rise to approximately $172 million on a monthly basis. In linear terms, this comes to more than $2 billion per annum, just as a result of the volatility savings.

Report Extracts

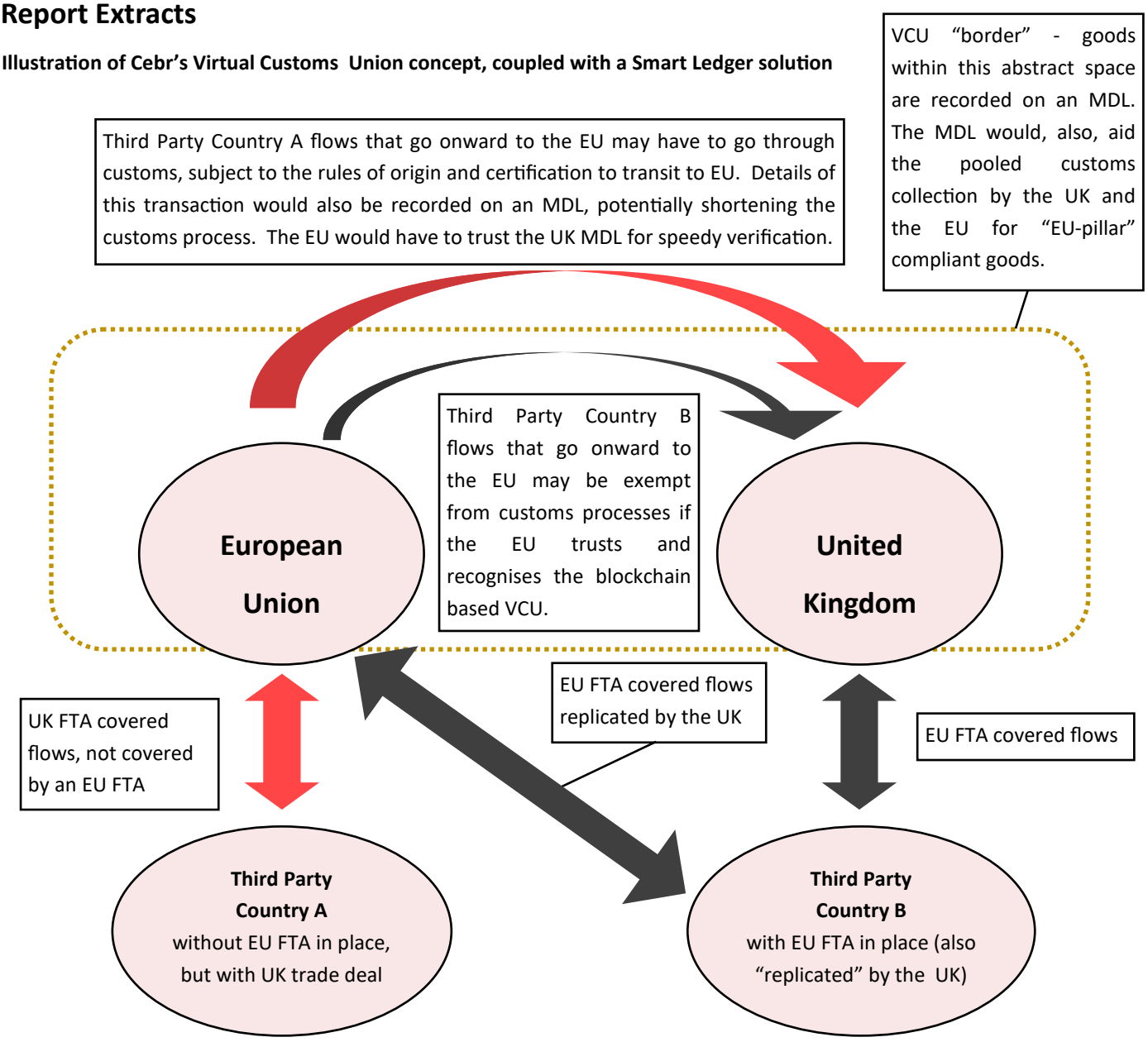
Methodological Background And Econometric results



	Global USD GDP Uplift	Current Global GDP (USD bn)	Potential Global Labour Market Impact
Low Scenario	10.33	79,281	449,319
High Scenario	20.66	79,281	898,639

Report Extracts

Illustration of Cebr's Virtual Customs Union concept, coupled with a Smart Ledger solution



Conclusions

- Smart Ledger technology could boost world trade in goods by at least $35 billion dollars per annum. The cost of importing a single container could, therefore, be reduced by around $46, by simplifying procedures.
- These potential benefits are driven by a 2.5% cost clawback assumption, supported by case studies on previous technological advancements in trade and industry feedback.
- If reduced uncertainty is, also, taken into account, using option pricing theory, the potential gains become even larger, with a potential monthly net cost saving of $172 million (or, approximately, $2 billion per annum).
- This would boost world GDP by $10 to $20 billion and could, potentially, add between 450,000 and 900,000 to the worldwide demand for labour, boosting wages and living standards worldwide.

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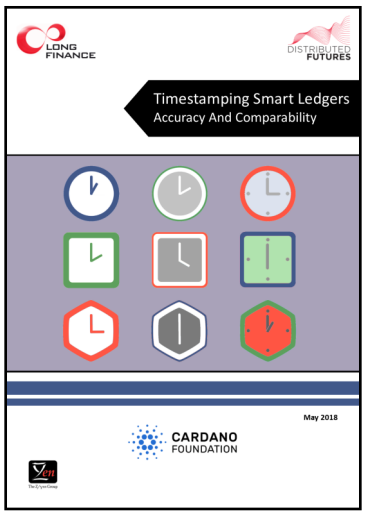
Timestamping Smart Ledgers

"The only reason for time is so that everything doesn't happen all at once" – Albert Einstein. Thanks to the synergy of Timestamping and Smart Ledgers, there is now a way to accurately track and immutably record various incidents across a multitude of industries. This report sheds light on the challenges produced by Timestamping and Smart Ledgers, as well as the many benefits they yield.

Overview



The report outlines current and historic methods for recording the time of an event, as well as the challenges that will be faced in the future. In the world of finance, these challenges include the stringent transaction timestamping requirements laid down by MiFID II Article 25 (or "RTS 25"). In geolocation, the interaction with global positioning systems, themselves subject to relativistic and quantum effects, are equally challenging. For Smart Ledgers, recording the time of transactions is a fundamental feature, yet there are a number of definitions and options that managers choose, often unknowingly, when they instruct their teams.

As the standards for timestamping become more and more stringent, we will need to look to new technologies for help. The use of Smart Ledgers may prove a great boon for all market participants. Regulators will find it easy to enforce technological standards, even in areas as challenging as timestamping.

The report is designed to produce materials that should help senior business people and policy makers understand why timestamping matters.

Report Extracts

A Timestamping Scheme Should Be C.U.T.I

Comparable - Timestamps only become useful when being compared to each other. A timestamping system that records the times of events would not only have to use a universal clock to guarantee *accuracy*, but would also have to provide each timestamp with a specified level of *precision*. Without these guarantees, there is the danger of disputes when attempting to compare two times.

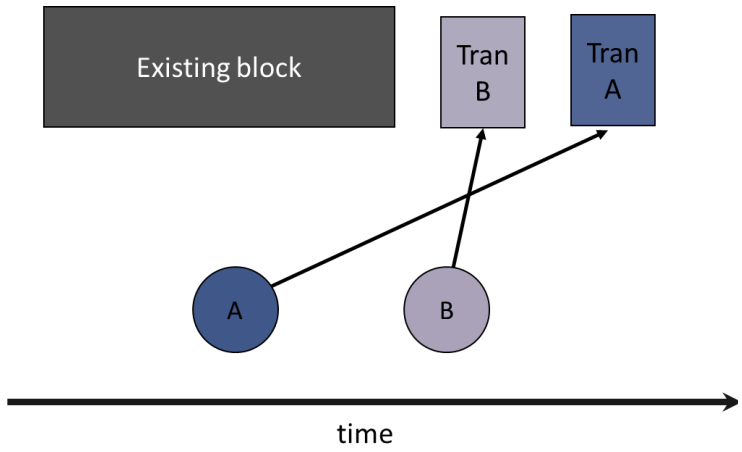
Universal - A timestamp on a document, smart contract, or transaction must be independent of the technology that applied it. Any two interacting systems are going to have to be able to marry up their timestamps with each other, irrespective of the technological mechanisms used by each.

Traceable - To ensure time traceability, every step back to the reference clock must be known and documented. It is easier to guarantee traceability with services such as NPLTime®, which certifies the time signal's traceability to UTC. To ensure traceability with GPS is more difficult. In order to ensure traceability to a central atomic time source, a user would need to have an appreciation of the latencies present in its own internal and external systems.

Immune - A large infrastructure has been set up worldwide, so that any system plugged into it can identify what the time is. It is therefore incumbent upon anyone recording the time of an event to ensure that the timestamp they use is immune from interference by a third party. A timestamp should be impossible to change after it has been applied.

Report Extracts (Continued)

A Transaction With A Timestamp That Differs From The Posting Time



In the above Figure, transaction A occurs, is timestamped, and submitted to the network before transaction B. However, because the client who submitted transaction A is suffering from high latency, transaction A ends up sitting "after" transaction B in the audit trail.

Any timestamping system will have a specified precision. It is therefore possible that two events submitted by different users are timestamped so that they appear to have taken place at the same time. In such cases, in order to work out precedence, the Smart Ledger will have to fall back on its chronological audit sequence. The audit trail model ensures that the transactions would have to have been added in one order or another.

Conclusions

Throughout the history of timekeeping, two important metrics have been vital to the success of any technology: accuracy and precision. Whenever new timekeeping technologies arrive, their accuracy and precision must be evaluated anew. In a sense, accuracy is a measure of consistency with external standards, and precision a measure of inner consistency.

The time parameters and timestamps of smart contracts and transactions cannot be compared with one another, unless the standards of precision and accuracy are applied to all of them. If a user wishes to post a smart contract to a smart ledger, it is vital that the contract abides by the "time rules" of the ledger. Otherwise, since comparability is impossible, the transactions, contracts, and assets cannot exist in the same universe.

In the world of finance, required standards of accuracy and precision are rigorously set out by regulatory groups such as ESMA and the FCA. This means that if any new technology is to be taken seriously in the financial world, it must be capable of meeting these minimum requirements. Indeed, the sequential nature of Smart Ledgers renders some of the precision standards redundant, since the ledgers have to store transactions in the order received.

However, the distributed nature of the technology does mean that the questions of latency and synchronisation need to be even more carefully considered than a legacy, non-distributed system. This is especially true if the system is to be used in a financial system supervised by MiFID II.

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